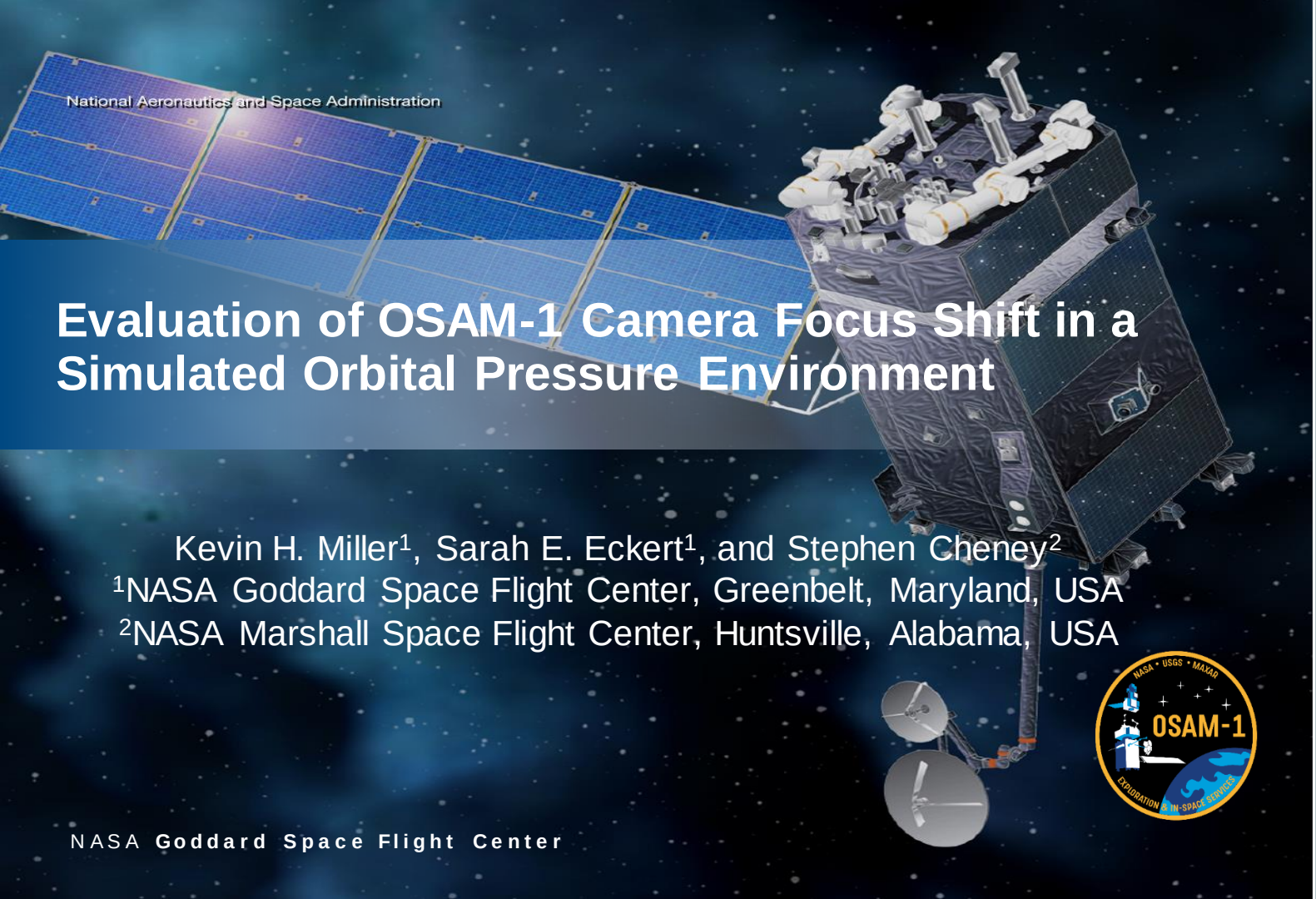

Evaluation of OSAM-1 Camera Focus Shift in a Simulated Orbital Pressure Environment

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NASA **Goddard Space Flight Center**

OSAM-1

Outline

- OSAM-1 Overview & Concept of Operations
- Long Range Inspection Camera & Test Motivation
- Test Facility & Configuration
- Results
- Conclusions

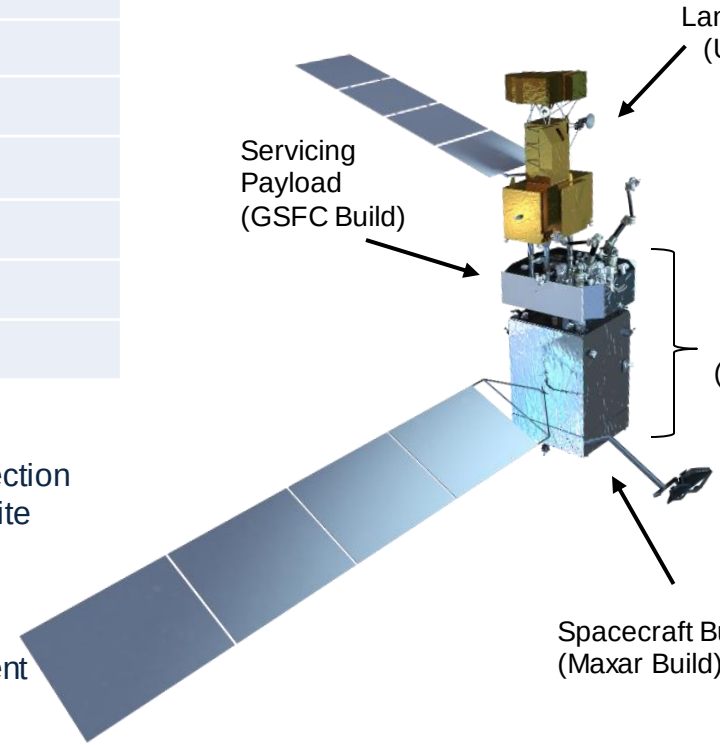
OSAM-1 Mission Overview

Category/Class	Category 1 / Class C
Mission Life	1 year
Launch	2026
Launch Vehicle	Atlas V or Falcon-9
Launch Site	VAFB or KSC
Servicing	Landsat 7
Assembly	Ka Antenna
Manufacturing	Beam

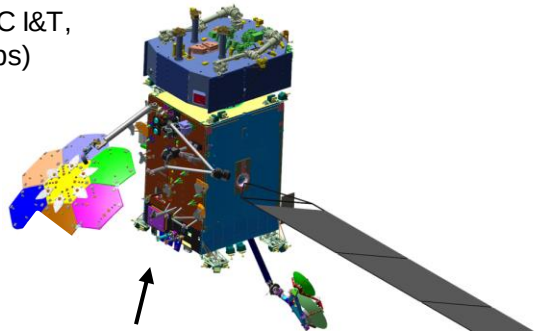
OSAM-1 will demonstrate:

- Autonomous rendezvous and inspection
- Autonomous capture of client satellite
- Tele-operated robotic servicing
- Refueling of client satellite
- Relocation of client satellite
- Release and safely depart from client
- On-orbit assembly of an antenna
- On-orbit manufacturing of a beam

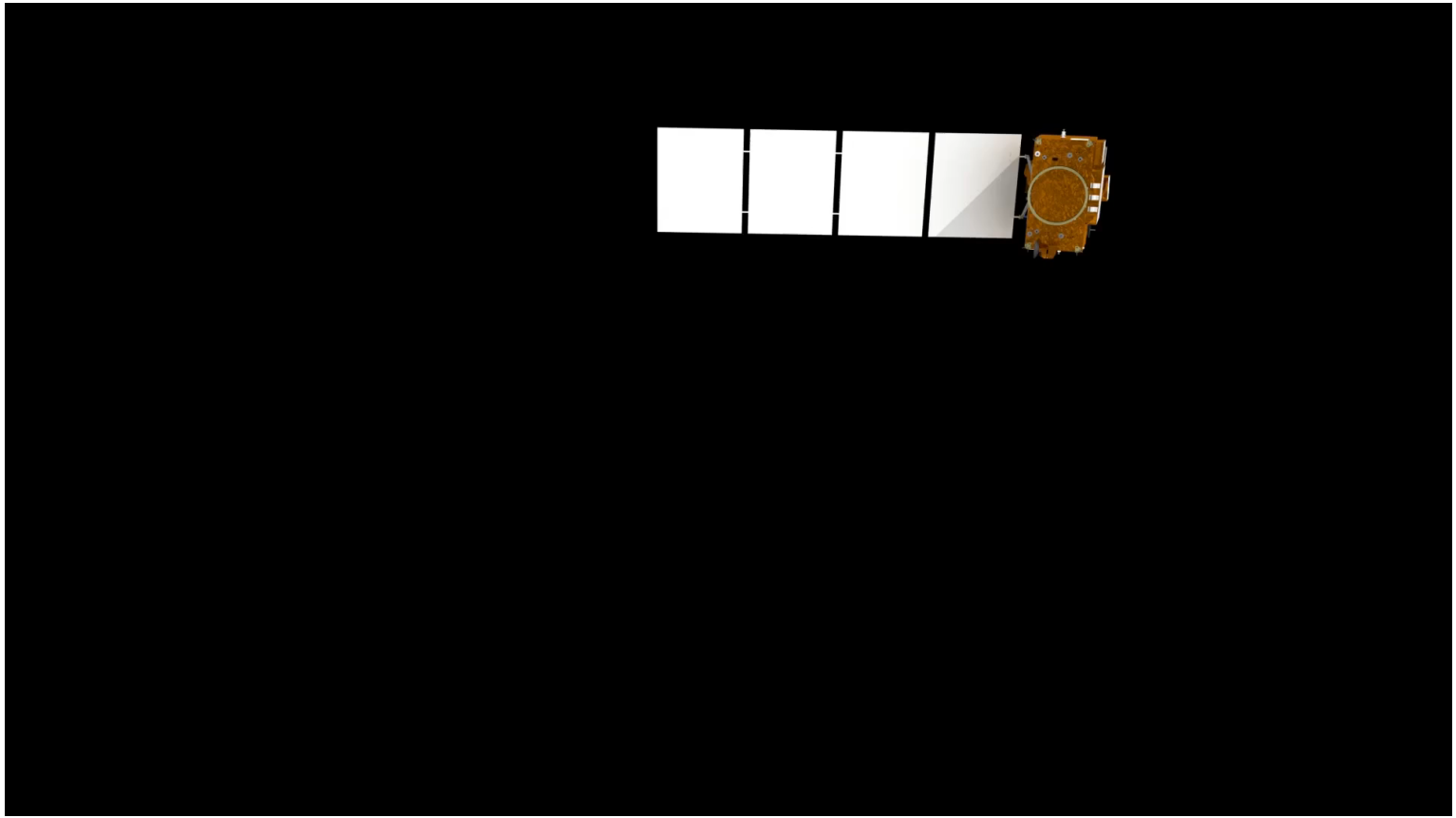
Robotic Servicing



Assembly and Manufacturing



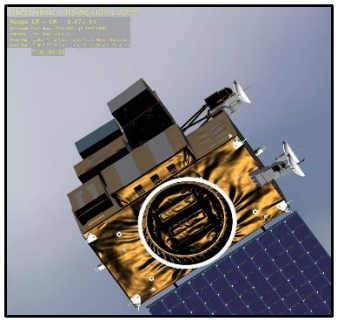
OSAM-1 Concept of Operations: Servicing



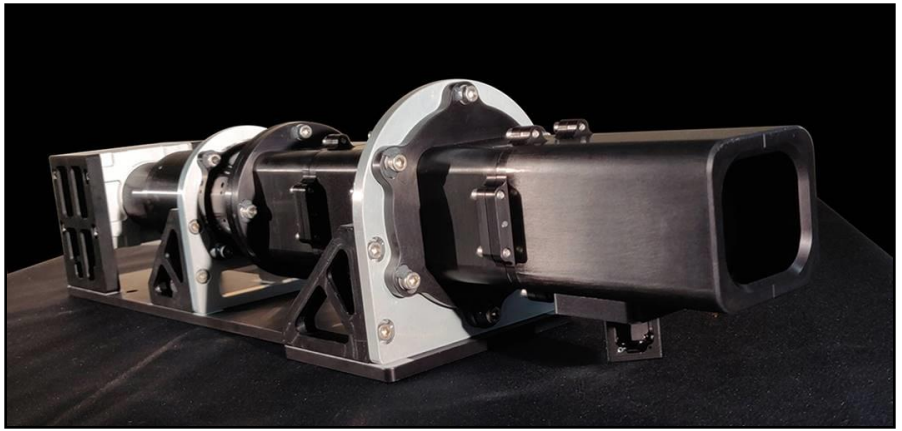
Long Range Inspection Camera (LRIC) Overview

- LRIC is a custom instrument that will meet the long-range inspection requirements of OSAM-1; namely, to detect a 1 cm sized object at 100 m distance.

LRIC Component Specifications	
Camera:	Malin Space Science Systems (MSSS) VSS Camera
Detector:	ON-Semi Python 5000
Type:	Color CMOS w/ global shutter
Resolution:	2592 (H) x 2048 (V) pixels
Pixel Pitch:	4.8 µm
ADC:	On-chip 8 or 10 bit
Optics:	Custom Lens Design by Ruda Cardinal, Inc.
Focal Length:	182 mm
Field of View:	3.0º (H) x 3.0º (V)
Aperture:	f/8.5
Focus Distance:	84 meters
Depth of Field:	~60 m - ~150 m
Optical Design:	x7 optical elements, designed to withstand space env.
Baffle:	1000:1 out-of-field stray light rejection
Coating:	Z306 Paint
Focus Spacer:	Interchangeable vacuum & air focus spacers



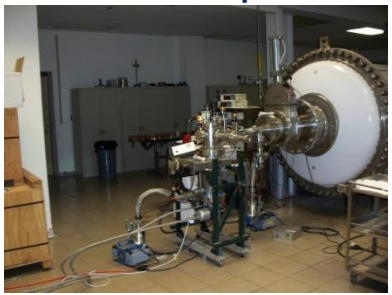
LRIC FOV at 100 m

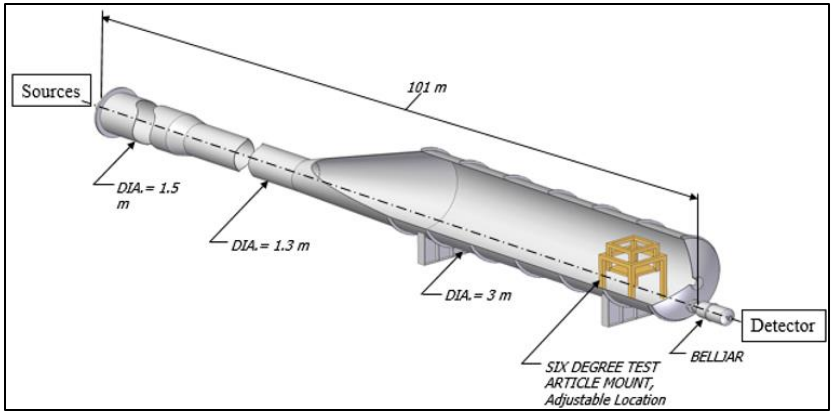


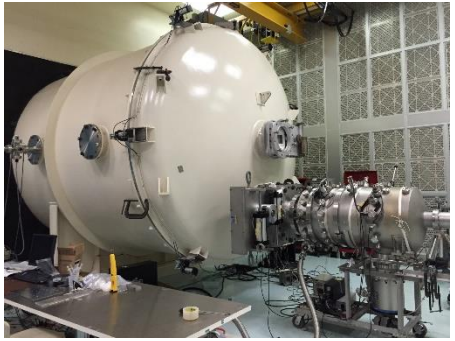
LRIC Engineering Test unit

Test Facility

- NASA Marshall Space Flight Center's Stray Light Test Facility
  - 101 m long vacuum chamber built in late 60's
  - Combination of rotary, turbo & cryo pumps achieve 10^{-7} Torr base pressure
  - 40x ports of various sizes for feedthroughs, etc.

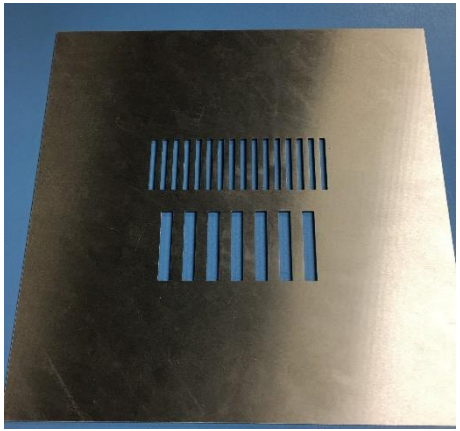






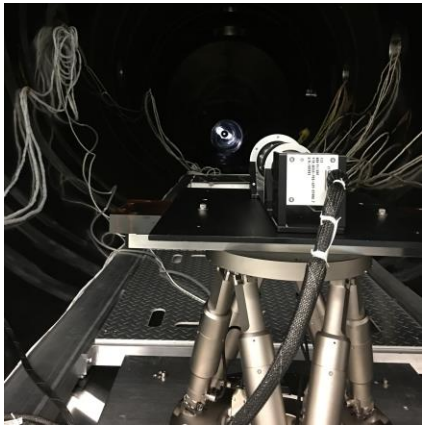
Test Configuration

- Target with 1 & 2 cm line pair knockouts fixed to outside of source window
- Collimated light from return of OAP back illuminated target
  - Energetiq EQ99 light source with translucent window
- LRIC mounted on hexapod 1 m inside of detector side chamber door
  - Images captured at various exposure times, bit depths, and pressures



Sheet Metal Target

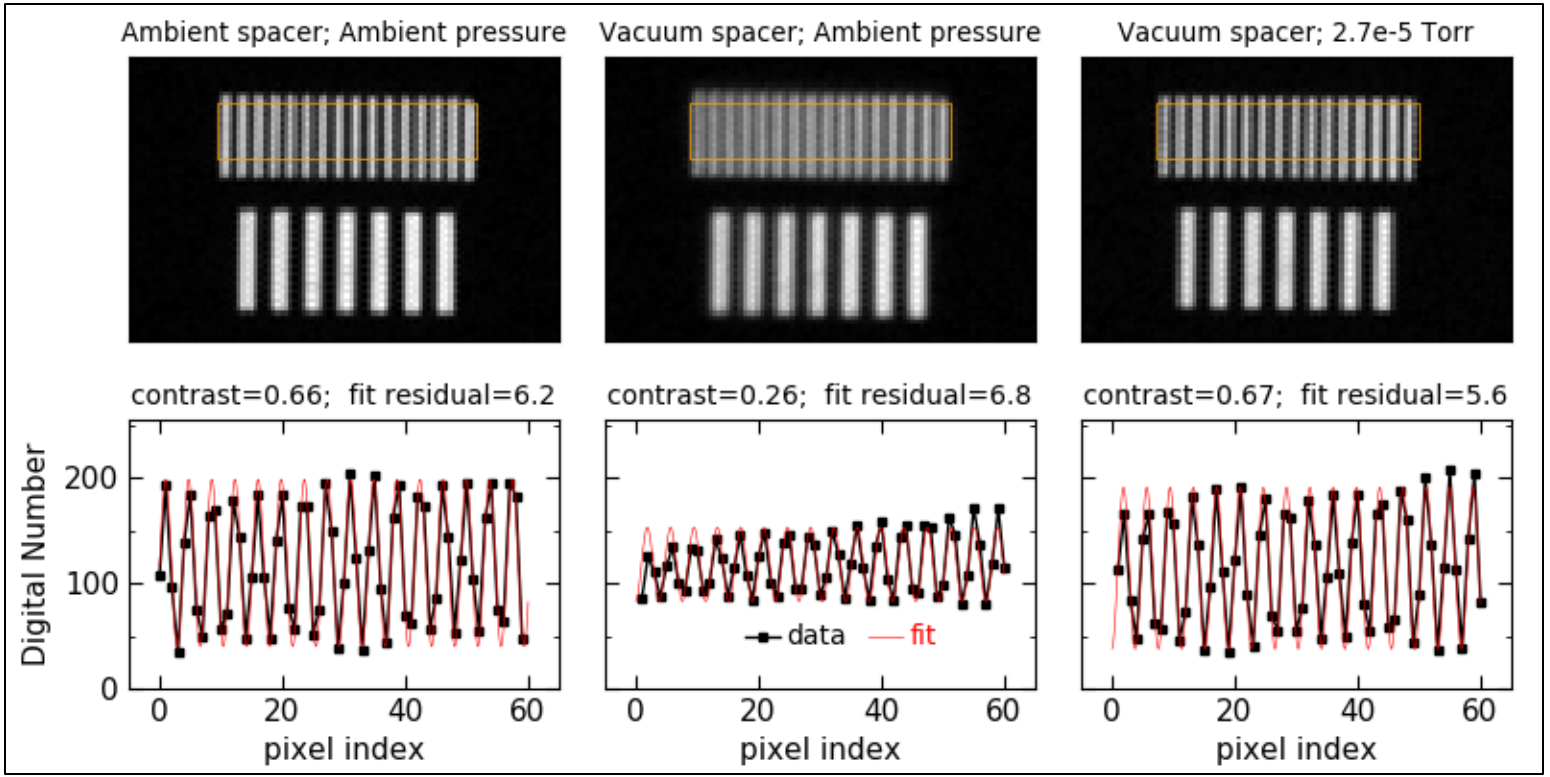
Source End



Detector End

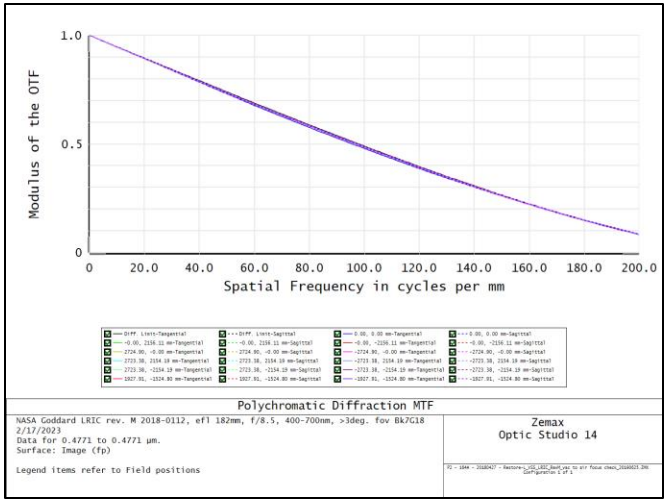
Air Spacer in Air vs. Vacuum Spacer in Vacuum

- Bar target contrast in air (air spacer) is within 1% of that in vac (vac spacer)



Model (MTF) vs. Measurement (Contrast)

- Bar target contrast is not equivalent to Modulation Transfer Function (MTF)
  - A relative comparison between the two metrics is made easier for a diffraction limited system with no center obscuration
- Error terms added in quadrature and propagated through contrast equation

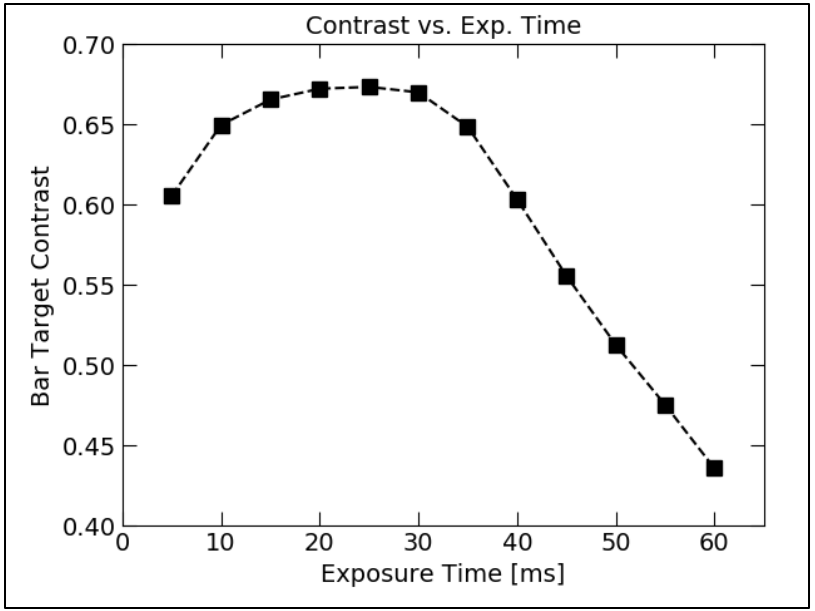


Lens-only MTF from model

Configuration	Predicted System MTF	Measured Contrast
Air spacer, 760 Torr	0.63	0.66 ± 0.10
Vac spacer, 760 Torr	0.21	0.26 ± 0.05
Vac spacer, 2.7×10^{-5} Torr	0.63	0.67 ± 0.09

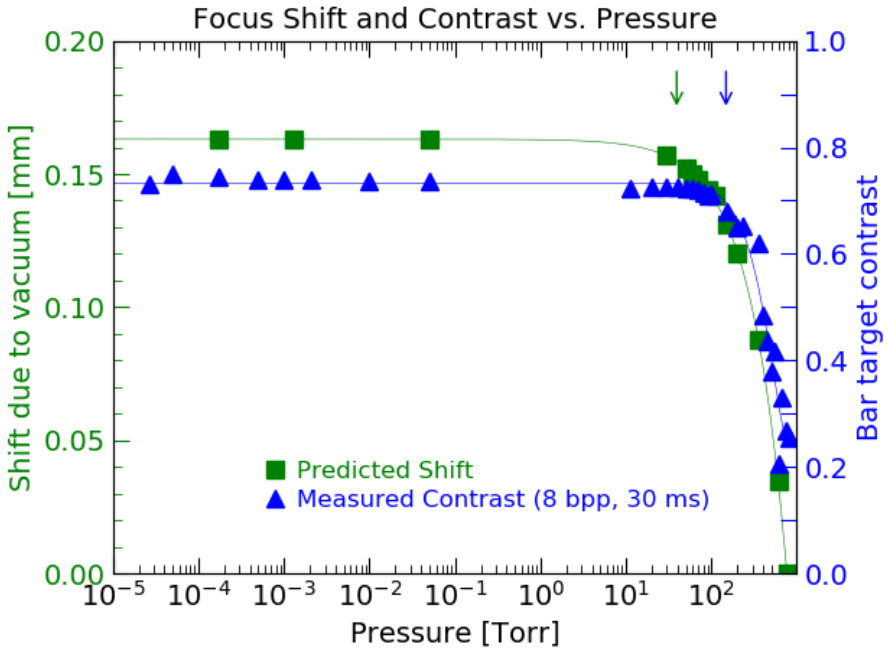
Optimum Exposure Time

- Bar target response is a function of camera exposure time
  - With increasing exposure time, the contrast reaches a max then declines due to increasing bias level
  - Optimum exposure time determined to be 25 ms



Predicted Focus Shift & Contrast vs. Pressure

- Predicted focus shift vs. pressure (model) levels-off at a 39 Torr; Measured contrast vs. pressure levels off at 147 Torr
  - Difference may be attributed to depth of focus of lens.



Conclusions

- Bar target contrast of back-illuminated 1 cm line pair pattern at 100m in vacuum (vac spacer) recovers to within 1% of values in air (air spacer).
  - Validates model used to determine spacer thickness.
- Demonstrated ability to detect a 1 cm object with an acceptable contrast in a static scene.
  - Predicted 5 ms exposure on-orbit bounds motion MTF loss.
- Compared measured contrast vs. pressure to modeled focus shift vs. pressure
  - Hypothesis of leveling-off pressure linked to depth of focus.